

CLINICAL REPORT

# Fabricating a tooth- and implant-supported maxillary obturator for a patient after maxillectomy with computer-guided surgery and CAD/CAM technology: A clinical report



Kwantae Noh, DMD, MSD, PhD,<sup>a</sup> Ahran Pae, DMD, MSD, PhD,<sup>b</sup> Jung-Woo Lee, DMD, MSD, PhD,<sup>c</sup> and Yong-Dae Kwon, DMD, MSD, PhD<sup>d</sup>

Patients with severe maxillary defects after tumor resection have problems with speech, mastication, swallowing, and facial esthetics.<sup>1-4</sup> An obturator prosthesis is the most common treatment option for these patients because factors such as hospitalization, risk of complications, treatment time, systemic conditions, and patient refusal may make the surgical reconstruction of maxillary defects impossible.<sup>5</sup> However, in patients with extensive palatomaxillary resections, these obturators tend to be unstable because of the lack of contralateral mucogingival support.<sup>6-8</sup>

Osseointegrated implants can enhance the stability and retention of maxillary obturators and, as a result, improve the function of the prostheses and the quality of life of patients with maxillary defects.<sup>1,9-14</sup> However, the available implant sites for maxillectomy patients are usually limited. In fact, the root of the zygomatic arch may be the only available site for implant placement.<sup>1,15</sup> Other than the limitation of available implant sites, restricted intraoperative vision, anatomic complexity, and the variability of the zygomatic bone make implant surgery a demanding procedure.<sup>16,17</sup> Any minor errors (such as incorrect drill angle) can result in significant positional

## ABSTRACT

An obturator prosthesis with insufficient retention and support may be improved with implant placement. However, implant surgery in patients after maxillary tumor resection can be complicated because of limited visibility and anatomic complexity. Therefore, computer-guided surgery can be advantageous even for experienced surgeons. In this clinical report, the use of computer-guided surgery is described for implant placement using a bone-supported surgical template for a patient with maxillary defects. The prosthetic procedure was facilitated and simplified by using computer-aided design/computer-aided manufacture (CAD/CAM) technology. Oral function and phonetics were restored using a tooth- and implant-supported obturator prosthesis. No clinical symptoms and no radiographic signs of significant bone loss around the implants were found at a 3-year follow-up. The treatment approach presented here can be a viable option for patients with insufficient remaining zygomatic bone after a hemimaxillectomy. (J Prosthet Dent 2016;115:637-642)

errors for the implant and cause damage to anatomic structures, including the orbital floor.

Implantation surgery guided by computer-assisted virtual planning can help simplify this type of surgical procedure. Presurgical implant planning and correct communication between the surgeon and prosthodontist can be improved using 3-dimensional (3D) implant planning software and cone beam computed tomography (CBCT) data.<sup>18-22</sup> Stereolithographic surgical guides for implant placement are manufactured on the basis of virtual planning data and have become popular with the development of computer-aided design/computer-assisted manufacture (CAD/CAM) technology.<sup>22-24</sup>

Zygomatic implants have proven to be an effective option for the rehabilitation of patients with extensive maxillary defects caused by tumor resections, trauma,

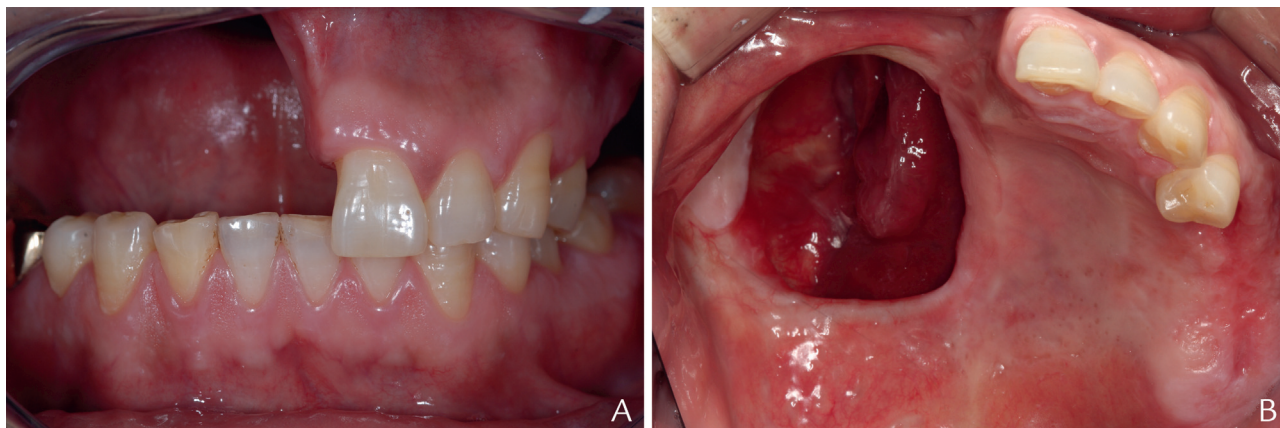
Supported by a Korea Health Technology R&D project grant (HI14C0175) through the KHIDI, funded by the Ministry of Health and Welfare, Republic of Korea.

<sup>a</sup>Assistant Professor, Department of Prosthodontics, School of Dentistry, Kyung Hee University, Seoul, Republic of Korea.

<sup>b</sup>Associate Professor, Department of Prosthodontics, School of Dentistry, Kyung Hee University, Seoul, Republic of Korea.

<sup>c</sup>Assistant Professor, Department of Oral and Maxillofacial surgery, School of Dentistry, Kyung Hee University, Seoul, Republic of Korea.

<sup>d</sup>Professor and Chairman, Department of Oral and Maxillofacial surgery, School of Dentistry, Kyung Hee University, Seoul, Republic of Korea.



**Figure 1.** Preoperative condition. A, Frontal view. B, Occlusal view.

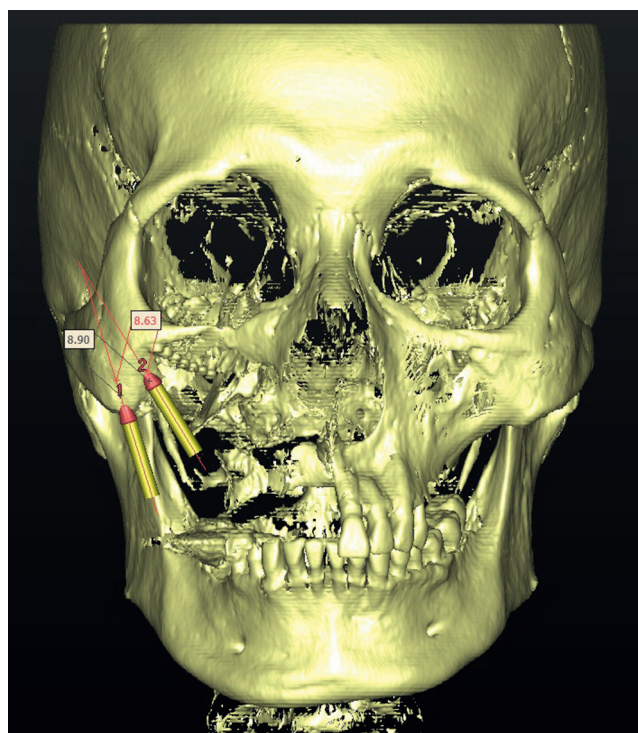
and congenital conditions.<sup>13,16</sup> However, zygomatic implants cannot be used when insufficient or unsatisfactory zygomatic bone remains after a maxillectomy.<sup>15</sup> With the progress of surface-treatment technology, implants of a general length can be used in the reconstruction of maxillary defects.

When standard implants are used in the zygoma, prosthetic procedures with conventional healing abutments and impression copings are often difficult because of the thick transmucosal region. In these patients, customized abutments and copings may be required for prosthesis fabrication. With CAD/CAM technology, the manufacture of customized components can be simplified. This clinical report describes the use of computer-assisted planning and surgery combined with prosthetic procedures applying CAD/CAM technology to the customization of healing abutments, impression copings, and milled titanium bar.

## CLINICAL REPORT

A man in his early forties with an unstable maxillary obturator prosthesis presented at the Department of Prosthodontics, Kyung Hee University Dental Hospital. The patient had a large defect involving most of the right hard palate and opening into the nasal cavity (Fig. 1). The 4 teeth in the maxilla from the left central incisor to the left first premolar were unaffected. The extraoral examination revealed right maxillary facial depression, and radiographic examination identified a large defect of the right maxilla with minimal remaining zygomatic bone.

The patient had undergone a hemimaxillectomy on the right side for resection of odontogenic myxoma in 2004 at the Department of Oral and Maxillofacial Surgery. After resective surgery, the patient was rehabilitated with a tooth-retained obturator in 2005. However, during the follow-up period, the retaining teeth showed poor prognosis, because the absence of contralateral mucogingival support had caused the local cantilever to be

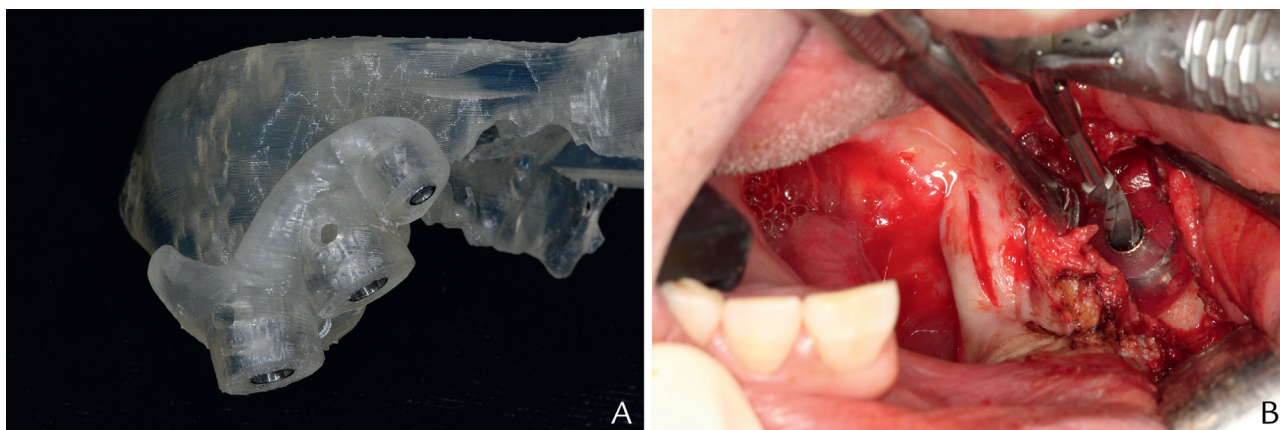


**Figure 2.** Virtual implant planning using SimPlant software. Three-dimensional CT scan revealed small amount of zygomatic bone on defect side. CT, computed tomography.

overloaded. In 2011, the left second premolar, left first molar, and left second molar, which were the main anchor teeth for the obturator, were extracted, and the affected area was repaired with artificial teeth.

Considering the stability, retention, load distribution, cantilever loading, and longevity of the superstructure, the decision was made to rehabilitate the patient with an implant- and tooth-supported obturator prosthesis. For load distribution to the contralateral side, implant placement was planned in the remaining zygomatic bone and milled titanium bar.





**Figure 3.** A, Bone-supported stereolithographic surgical stent. B, Implant placement in remaining zygoma using surgical stent.

A CT scan identified the portion of the remaining zygomatic bone on the defective side (Fig. 2). Conventional implant placement without computer-assisted surgery was considered to be complex and dangerous because of the inaccessibility and anatomic constraints in the area. To ensure proper positioning and anchorage of the implants, computer-assisted surgery was planned. The patient's CT scans were converted into digital images with software (SimPlant; Materailise) and were used to plan the surgery. After 3D modeling, virtual surgery was performed to properly position the dental implants. Two implants (Straumann Standard Implant; diameter: 4.1 mm; length: 10 mm; Straumann AG) were carefully positioned using the software (Fig. 2) to reduce the cantilever force and overloading. Zygomatic implants were not considered a treatment option for this patient because of insufficient bone support for anchorage. The planned data were sent to a manufacturing facility (Materialise), and bone-supported surgical guides with titanium guide sleeves were prepared (Fig. 3).

After flap elevation, the stability and fit of the bone-supported surgical template was verified while the patient was under general anesthesia. Then the surgical template was fixed with anchor pins to the underlying bone. Implant beds were prepared, and the 2 implants were installed (Straumann Standard Implant; SLActive surface; diameter: 4.1 mm; length: 10 mm; Straumann AG) (Fig. 3). A postoperative CT scan was obtained to verify the correct positioning and angle of the implants in the zygomatic bone. All implants were submerged during the healing period.

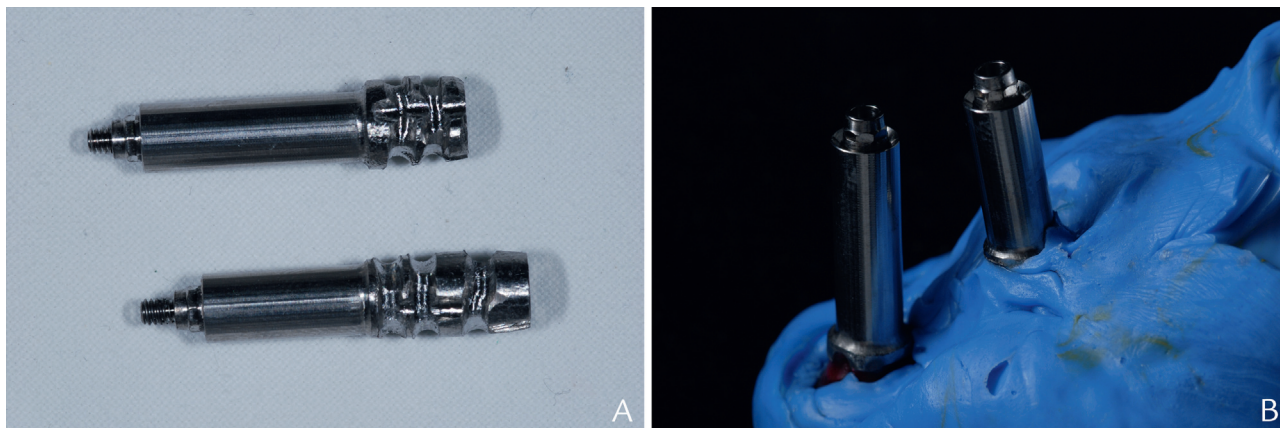
During the 2.5-month healing period, the remaining anterior teeth were prepared for splinted surveyed crowns for maximum support and stability. After the healing period, the implants in the zygoma were surgically exposed. Because of the thick soft tissue caused by extensive resection, customized titanium healing abutments were fabricated using CAD/CAM technology



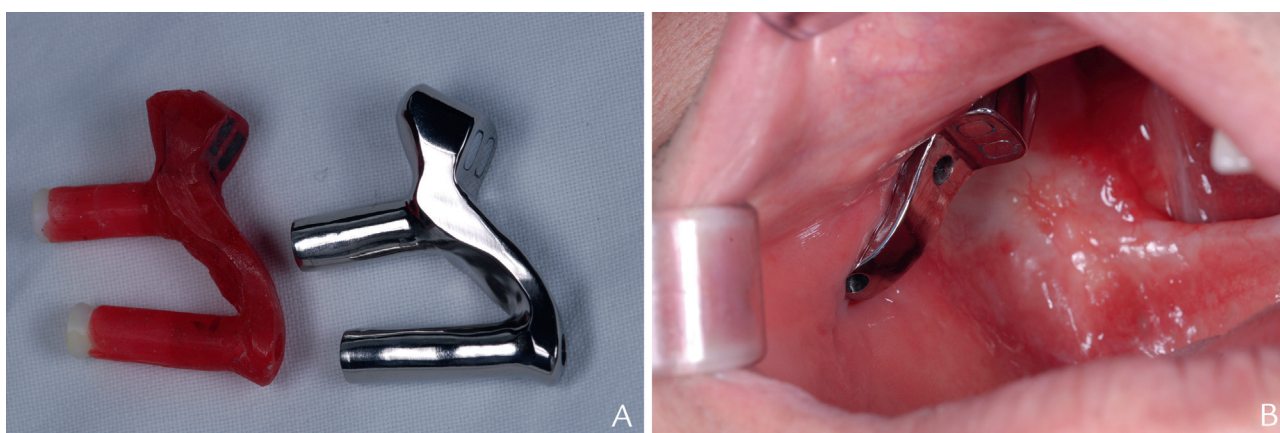
**Figure 4.** Customized titanium healing abutments.

before surgery (Fig. 4). The height of the healing abutments was predetermined from the CT data.

Definitive impressions were obtained for the surveyed crowns and the milled titanium bar on the defective side. Impression making of the implants placed in the zygoma was hindered by the soft tissue covering, and customized impression copings were required. Each coping was designed based on the gingival height and milled from titanium to a length of 25 mm using CAD/CAM technology (Raphabio) (Fig. 5). The definitive casts were obtained and transferred to a semiadjustable articulator (KaVo PROTAR Revo7; KaVo), screw abutments (syn-Octa; Straumann AG) were secured, and plastic sleeves were connected to the implant analogs of the defective side. Autopolymerizing acrylic resin (GC Pattern Resin; GC Corp) was placed over the plastic sleeve copings, and a bar with a long transmucosal portion was fabricated for double scanning (Fig. 6). On the milled bar, a housing for the 2 magnetic attachments was designed, and the fit of the acrylic resin bar was verified intraorally. The wax pattern and the definitive cast were sent to a milling center for scanning. The outline of the milled bar was scanned with an optical scanner (Myscan; Raphabio),



**Figure 5.** A, Customized titanium impression copings. B, Definitive impression using customized impression copings.



**Figure 6.** A, Customized milled titanium bar was fabricated from double scanning. B, Intraoral view of customized milled titanium bar.

and the implant-bar connection was scanned with a contact scanner (Renishaw plc). A titanium bar that duplicated the pattern resin bar was fabricated with computer-assisted milling (DMU 60 Evo Deckel Maho; DMG America) (Fig. 6).

The surveyed crowns were cemented, and the milled titanium bar was connected to the implants. The passive fit of the milled titanium bar was verified. Border molding was done with modeling plastic impression compound (Kerr Corp). The definitive impression was made for the fabrication of the metal framework of the obturator. After the maxillomandibular relationship had been recorded, the arrangement of the artificial teeth was evaluated intraorally to verify the position, esthetics, and occlusion. The definitive obturator prosthesis was inserted, and magnetic attachments (Magfit EX 400; Aichi Steel) were fixed to the obturator prosthesis with an autopolymerizing acrylic resin (GC Pattern Resin; GC America Inc).

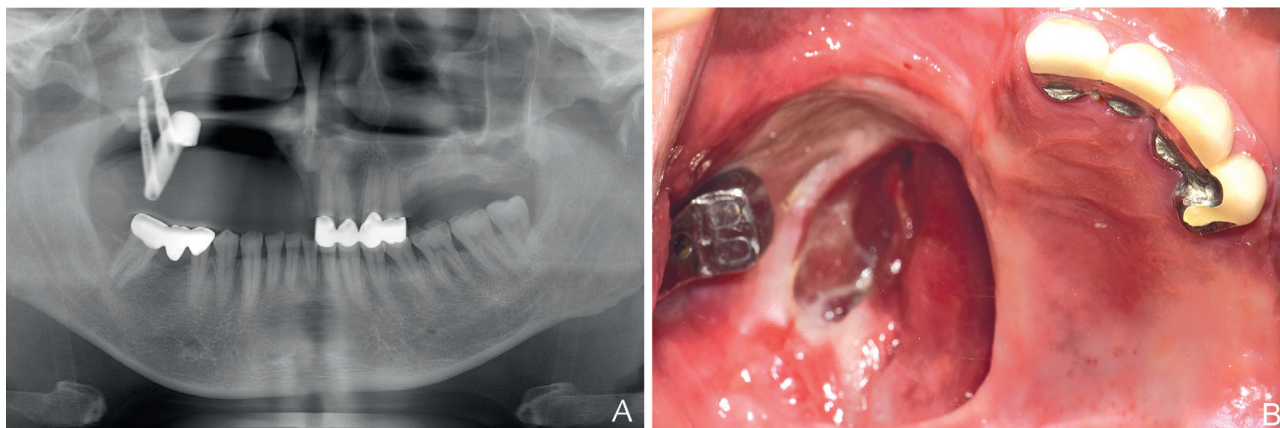
Satisfactory obturation of the defect was verified by speech performance and the absence of nasal leakage during swallowing (Fig. 7). The lack of attached gingiva around the milled titanium bar and the limited



**Figure 7.** Definitive obturator prosthesis.

accessibility may lead to gingival problems surrounding the implant; therefore, oral hygiene procedures were emphasized to avoid soft tissue complications. Three years after the procedure, no clinical symptoms and no radiographic signs of significant bone loss surrounding





**Figure 8.** Three years after definitive prosthesis. A, Panoramic radiograph of implants placed in zygoma. B, Occlusal view without obturator. Minor wear on milled titanium bar was observed.

the implants were observed (Fig. 8). Based on patient-satisfaction questionnaires, the obturator was rated as excellent.

## DISCUSSION

By placing 2 implants in the zygoma, favorable support was achieved, which minimized the nonaxial force for the teeth adjacent to the defect. Although computer-assisted surgeries have the advantages of better preparation, improved surgical outcomes, and shorter operation times, some clinicians may be concerned about the additional steps and cost-effectiveness of this technology.<sup>21</sup> However, even experienced surgeons with excellent free-hand surgery can benefit from this technology, particularly in patients with severely altered anatomies and juxtaposed structures (in this patient, the eye).

The planned data acquired from the virtual simulation can be transferred to the surgical sites by using dynamic navigation real-time tracking systems or a static transfer technique based on the surgical template, as in this patient.<sup>22</sup> Some authors have reported the use of computer navigation surgery using a real-time tracking system for implantation to the zygomatic bone.<sup>9</sup> However, real-time intraoperative navigation surgery requires a sophisticated and complex tracking system. Such an approach would also require longer preoperative times and higher operating costs than operations using surgical templates.

## SUMMARY

Cross-arch stabilization with a rigid splint framework is recommended to improve the long-term survival rates of implants in patients after a maxillectomy.<sup>1,17,25</sup> In this patient, direct splinting of the zygomatic implants with the remaining tooth on the contralateral side was technically difficult, and the success of splinting was doubtful. To minimize the nonaxial overload delivered to the implants of the zygoma, 2 implants were splinted with a

milled titanium bar and a short-cantilevered design. The leverage force on the implants of the zygoma was minimized with an accurate metal framework connecting all of the implants and surveyed crowns. Furthermore, the overload of the implant was minimized by the close adaptation and maximal extension of the obturator.<sup>1</sup> The crestal bone level around both implants was stable, and no mechanical complications occurred during the 3-year follow-up period.

## REFERENCES

1. Roumanas ED, Nishimura RD, Davis BK, Beumer J III. Clinical evaluation of implants retaining edentulous maxillary obturator prostheses. *J Prosthet Dent* 1997;77:184-90.
2. Desjardins RP. Early rehabilitative management of the maxillectomy patient. *J Prosthet Dent* 1977;38:311-8.
3. Desjardins RP. Obturator prosthesis design for acquired maxillary defects. *J Prosthet Dent* 1978;39:424-35.
4. Rieger J, Wolfaardt J, Seikaly H, Jha N. Speech outcomes in patients rehabilitated with maxillary obturator prostheses after maxillectomy: a prospective study. *Int J Prosthodont* 2002;15:139-44.
5. Swartz WM, Banis JC, Newton ED, Ramasastry SS, Jones NF, Acland R. The osteocutaneous scapular flap for mandibular and maxillary reconstruction. *Plast Reconstr Surg* 1986;77:530-45.
6. Okay DJ, Genden E, Buchbinder D, Irken M. Prosthodontic guidelines for surgical reconstruction of the maxilla: a classification system of defects. *J Prosthet Dent* 2001;86:352-63.
7. Parr GR, Tharp GE, Rahn AO. Prosthodontic principles in the framework design of maxillary obturator prostheses. *J Prosthet Dent* 1989;62:205-12.
8. Aramany MA. Basic principles of obturator design for partially edentulous patients. Part I: classification. *J Prosthet Dent* 1978;40:554-7.
9. Kreissl ME, Heydecke G, Metzger MC, Schoen R. Zygoma implant-supported prosthetic rehabilitation after partial maxillectomy using surgical navigation: a clinical report. *J Prosthet Dent* 2007;97:121-8.
10. Fukuda M, Takahashi T, Nagai H, Iino M. Implant-supported edentulous maxillary obturators with milled bar attachments after maxillectomy. *J Oral Maxillofac Surg* 2004;62:799-805.
11. Mericske-Stem R, Perren R, Raveh J. Life table analysis and clinical evaluation of oral implants supporting prostheses after resection of malignant tumors. *Int J Oral Maxillofac Implants* 1999;14:673-80.
12. Weischer T, Schettler D, Mohr C. Titanium implants in the zygoma as retaining elements after hemimaxillectomy. *Int J Oral Maxillofac Implants* 1997;12:211-4.
13. Schmidt BL, Pogrel MA, Young CW, Sharma A. Reconstruction of extensive maxillary defects using zygomatic implants. *J Oral Maxillofac Surg* 2004;62:82-9.
14. Örtorp A. Three tumor patients with total maxillectomy rehabilitated with implant-supported frameworks and maxillary obturators: a follow-up report. *Clin Implant Dent Relat Res* 2010;12:315-23.

15. Leles CR, Leles JL, de Paula Souza C, Martins RR, Mendonça EF. Implant-supported obturator overdenture for extensive maxillary resection patient: a clinical report. *J Prosthodont* 2010;19:240-4.
16. Landes CA. Zygoma implant-supported midfacial prosthetic rehabilitation: a 4-year follow-up study including assessment of quality of life. *Clin Oral Implant Res* 2005;16:313-25.
17. Parel SM, Brånemark PI, Ohnrell LO, Svensson B. Remote implant anchorage for the rehabilitation of maxillary defect. *J Prosthet Dent* 2001;86:377-81.
18. Parel SM, Triplett RG. Interactive imaging for implant planning, placement, and prosthesis construction. *J Oral Maxillofac Surg* 2004;62:41-7.
19. Uckan S, Oguz Y, Uyar Y, Ozyesil A. Reconstruction of a total maxillectomy defect with a zygomatic implant-retained obturator. *J Craniofac Surg* 2005;16:485-9.
20. Vrielinck L, Politis C, Schepers S, Pauwels M, Naert I. Image-based planning and clinical validation of zygoma and pterygoid implant placement in patients with severe bone atrophy using customized drill guides. Preliminary results from a prospective clinical follow-up study. *Int J Oral Maxillofac Surg* 2003;32:7-14.
21. Hultin M, Svensson KG, Trulsson M. Clinical advantages of computer guided implant placement: a systematic review. *Clin Oral Implant Res* 2012;23:124-35.
22. Jung RE, Schneider D, Ganeles J, Wismeijer D, Zwahlen M, Hammerle CH, et al. Computer technology applications in surgical implant dentistry: a systematic review. *Int J Oral Maxillofac Surg* 2009;24:92-109.
23. Neugebauer J, Stachulla G, Ritter L, Dreiseidler T, Mischkowski RA, Keeve E, et al. Computer-aided manufacturing technologies for guided implant placement. *Expert Rev Med Devices* 2010;7:113-29.
24. Tso TV, Tso VJ, Stephens WF. Prosthetic rehabilitation of an extensive midfacial and palatal postsurgical defect with an implant-supported cross arch framework: a clinical report. *J Prosthet Dent* 2015;113:498-502.
25. Kovács AF. Clinical analysis of implant losses in oral tumor and defect patient. *Clin Oral Implants Res* 2000;11:494-504.

#### Corresponding author:

Dr Yong-Dae Kwon  
Department of Oral and Maxillofacial Surgery  
Center for Refractory Jawbone Diseases  
Kyung Hee University School of Dentistry  
130872 Seoul  
KOREA  
Email: yongdae.kwon@gmail.com

Copyright © 2016 by the Editorial Council for *The Journal of Prosthetic Dentistry*.

## Noteworthy Abstracts of the Current Literature

### Effectiveness of disinfectants on antimicrobial and physical properties of dental impression materials

Demajo JK, Cassar V, Farrugia C, Millan-Sango D, Sammut C, Valdramidis V, Camilleri J  
*Int J Prosthodont* 2016;29:63-7

**Purpose.** The aim of this study was to assess the antimicrobial activity of chemical disinfectants on alginate and silicone impression materials. The effect of chemical disinfectants on the dimensional stability of the impression materials was also assessed.

**Material and methods.** For the microbiologic assessment, impressions of the maxillary arch were taken from 14 participants, 7 using alginate and 7 using an addition silicone. The impressions were divided into three sections. Each section was subjected to spraying with MD 520 or Minuten or no disinfection (control), respectively. Antimicrobial action of the chemical disinfectants was assessed by measuring microbial counts in trypticase soy agar (TSA) media and expressing the results in colony-forming units/cm<sup>2</sup>. The surface area of the dental impressions was calculated by scanning a stone cast using computer-aided design/computer-assisted manufacture and analyzing the data using a custom computer program. The dimensional stability of the impression materials after immersion in disinfectants was assessed by measuring the linear displacement of horizontally restrained materials using a traveling microscope. The percent change in length over 3 hours was thus determined.

**Results.** Alginate exhibited a higher microbial count than silicone. MD 520 eliminated all microbes as opposed to Minuten. The bacterial growth after Minuten disinfection was almost twice as much for alginate than for addition silicone impressions. The chemical disinfectants affected the alginate dimensional stability. Minuten reduced the shrinkage sustained by alginate during the first hour of storage.

**Conclusions.** Alginate harbors three times more microorganisms than silicone impression material. Chemical disinfection by glutaraldehyde-based disinfectant was effective in eliminating all microbial forms for both alginate and silicone without modifying the dimensional stability. Alcohol-based disinfectants, however, reduced the alginate shrinkage during the first 90 minutes of setting. The current studies also propose another method to report the surface area based on accurate estimation by 3D image analysis.

Reprinted with permission of Quintessence Publishing.